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Research paper

Social anxiety is related to increased dwell time on socially threatening faces

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ABSTRACT

Background: Identification of reliable targets for therapeutic interventions is essential for developing evidence-based therapies. Threat-related attention bias has been implicated in the etiology and maintenance of social anxiety disorder. Extant response-time-based threat bias measures have demonstrated limited reliability and internal consistency. Here, we examined gaze patterns of socially anxious and nonanxious participants in relation to social threatening and neutral stimuli using an eye-tracking task, comprised of multiple threat and neutral stimuli, presented for an extended time-period. We tested the psychometric properties of this task with the hope to provide a solid stepping-stone for future treatment development.

Methods: Eye gaze was tracked while participants freely viewed 60 different matrices comprised of eight disgusted and eight neutral facial expressions, presented for 6000 ms each. Gaze patterns on threat and neutral areas of interest (AOIs) of participants with SAD, high socially anxious students and nonanxious students were compared. Internal consistency and test–retest reliability were evaluated.

Results: Participants did not differ on first-fixation variables. However, overall, socially anxious students and participants with SAD dwelled significantly longer on threat faces compared with nonanxious participants, with no difference between the anxious groups. Groups did not differ in overall dwell time on neutral faces. Internal consistency of total dwell time on threat and neutral AOIs was high and one-week test–retest reliability was acceptable.

Limitations: Only disgusted facial expressions were used. Relative small sample size.

Conclusion: Social anxiety is associated with increased dwell time on socially threatening stimuli, presenting a potential target for therapeutic intervention.

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1. Introduction

Threat-related attention bias is implicated in the etiology and maintenance of social anxiety disorder (SAD; Clark and Wells (1995) and Rapee and Heimberg (1997)), and has been identified as a target for therapeutic intervention in the form of attention bias modification treatment (ABMT; for reviews, see Bar-Haim (2010), Hakamata et al. (2010), Heeren et al. (2015) and Van Bockstaele et al. (2014)). Most of the evidence for biased attention in social anxiety comes from studies employing cognitive tasks that rely on reaction time (RT) data (for reviews, see Bar-Haim et al. (2007), Beard et al. (2012), Cisler et al. (2009) and Cisler and Koster (2010)). One drawback of RT-based tasks is the distal relation between the behavioral output (i.e., key presses) and the examined attentional processes, potentially giving rise to confounding elements such as motor preparation and response execution (Armstrong and Olatunji (2012)). In addition, because RT measures capture only one instance in time, at the very end of a complex cognitive-behavioral process, they do not reflect the dynamic nature of online attention allocation (e.g., Bar-Haim (2010), Bar-Haim et al. (2007), Shechner et al. (2013) and Yiend (2010)). These shortcomings of RT-based measures point to the need to find new and improved paradigms to assess and subsequently modify attentional biases in anxious individuals (Van Bockstaele et al., 2014).

Recently, studies using eye-tracking methodology attempted to overcome some of the above-noted limitations. For example, in a typical free viewing task participants are requested to observe arrays of neutral and threat stimuli without specific requirements or instructions while their gaze is being continuously recorded. Previous free viewing studies found evidence for greater attention to threat in socially anxious (SA) relative to nonanxious participants reflected in the more frequent and faster first fixations on threat, longer dwell time on threat first fixations, as well as total

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dwell time on socially threatening stimuli (for reviews, see Armstrong and Olatunji (2012) and Richards et al. (2014)). However, most of these studies utilized small stimulus set sizes made of only 2–4 stimuli, with usually only one stimulus of an emotional valence. The generalizability and ecological validity of such stimuli displays has been called into question by Richards et al. (2014), who recommended use of more complex visual displays with various competing threatening and non-threatening stimuli presented at once, thereby increasing resemblance of these displays to real-world situations. In addition, most free viewing studies have examined data pertaining to first fixations, or to fixations occurring within the first 500 ms of stimuli presentation (e.g., Bradley et al. (2000), Garner et al. (2006) and Stevens et al. (2011)). The three studies that examined gaze patterns across longer presentation periods provide initial evidence for increased total dwell time on socially threatening stimuli among socially anxious individuals (Buckner et al., 2010; Schofield et al., 2012; Wieser et al., 2009). However, the set sizes used in these three studies were small, ranging only 1–4 stimuli.

Here we recorded eye-tracking data during a free-viewing task using complex stimuli comprised of eight socially threatening faces and eight neutral faces, presented for an extended time period of 6000 ms. We measured overall dwell time on threat and neutral stimuli throughout this extended period, and also measured first-fixation variables: latency to first fixations, location of first fixations, and dwell time of first fixations. We tested a sample of high and low SA undergraduate students, as well as a sample of treatment seeking patients with SAD. Internal consistency of the task was evaluated, as well as one-week test–retest reliability. We predicted that: (a) relative to nonanxious participants, socially anxious participants would exhibit greater total dwell time on threatening faces, but not on neutral faces; and (b) relative to nonanxious participants the latency to first fixations of socially anxious participants would be shorter, first fixations would be more frequently located on threat faces relative to neutral faces, and would be longer. We hoped that reliable group differences on these measures would present a viable target for future intervention for SAD.

2. Methods

2.1. Participants

Participants in this study belonged to three groups: high and low socially anxious undergraduate students, and participants with clinically diagnosed SAD. Participants' self-reported social anxiety and depression scores (see Measures below) by group are presented in Table 1.

Three hundred and fifty three undergraduate students were screened for social anxiety using the Liebowitz Social Anxiety Scale (LSAS; Liebowitz (1987)). Students with LSAS score ≥ 63 constituted the high SA group ($n = 20$, 14 females, mean age $= 22.85$ years, $SD = 2.56$, range $= 20$–30). Whereas LSAS score above 30 is considered the clinical cutoff on this scale, we set our cutoff score at 63 as this score was reported to yield no false positive identification of SAD among non-SAD individuals (Mennin et al., 2002). Thus, this cutoff score enabled the enrollment of participants that most closely resemble the clinical population of interest. The low SA group consisted of students with LSAS score ≤ 16 ($n = 20$, 14 females, Mean age $= 22.05$ years, $SD = 1.76$, range $= 19$–26), reflecting those who scored at the bottom of the sampling pool, reflecting minimal social anxiety. All student participants received course credit for participation.

The clinical group consisted of 20 treatment seeking patients diagnosed with SAD (12 females, mean age $= 35.15$ years, $SD = 9.67$, range $= 21$–52). Primary and co-morbid diagnoses were ascertained using the Mini-International Neuropsychiatric Interview (see below, M.I.N.I; Sheehan et al. (1998)) administered by a clinical psychologist trained to 85% reliability criterion with a senior psychologist. SAD diagnosis was further ascertained using the LSAS (Liebowitz, 1987), with a cutoff score of 50 and higher as an inclusion criterion. This cutoff score is considered to represent good identification for SAD with optimal balance between specificity and sensitivity (Mennin et al., 2002; Amir and Taylor, 2012). Exclusion criteria for the clinical SAD group were: (a) age not between 18 and 60 years; (b) present or past psychotic episodes; (c) severe co-morbid depression with a high suicide risk; (d) co-morbid post-traumatic stress disorder (PTSD), obsessive-compulsive disorder (OCD), Tic disorder or Tourette's syndrome; (e) a neurologic condition (e.g., epilepsy, brain injury); (f) use of neuroleptic medication; and (g) drug or alcohol misuse, as defined by the MINI. Of the 20 participants with SAD included in the study, six also met criteria for a past or present depressive episode, one for dysthymia, ten for generalized anxiety disorder (GAD), two for panic disorder (PD), and four for agoraphobia. Five participants were using a stable dose of Selective Serotonin Reuptake Inhibitors (SSRIs).

Table 1
Psychopathological characteristics of the three groups.

Measure	High SA group		Low SA group		SAD group	
	M	*SD*	*M*	*SD*	*M*	*SD*
LSAS	76.40[a]	17.13	17.30[b]	12.91	74.20[a]	17.56
PHQ-9	9.20[a]	4.65	4.95[b]	5.03	10.55[a]	4.78

Note. Different superscripts signify differences between groups at $p < .001$. Same superscripts signify non-significant differences between groups at $p > .38$. SAD, social anxiety disorder; LSAS, Liebowitz Social Anxiety Scale; PHQ-9, Patient Health Questionnaire-9.

The study protocol was approved by the local Institutional Review Board and participants provided written informed consent. We only invited participants that had normal or corrected-to-normal vision, excluding usage of multi-focal eyewear to prevent eye-tracking calibration difficulties. None of the participants had prior experience with eye-tracking procedures.

2.2. Measures

2.2.1. Social anxiety

Social anxiety was measured using the self-report version of the LSAS (Liebowitz, 1987). The LSAS lists 24 socially relevant situations. Each situation is rated on two scales ranging 0–3: level of fear and level of avoidance provoked by the described situation. Items are rated in relation to the passing week. The LSAS has strong psychometric properties, including high internal consistency, strong convergent and discriminative validity, and high test–retest reliability (e.g., Baker et al. (2002), Fresco et al. (2001) and Heimberg et al. (1999)).

2.2.2. Depression

Depression was measured using the Patient Health Questionnaire-9 (PHQ-9; Kroenke et al. (2001) and Spitzer et al. (1999)). The PHQ-9 is a 9-item self-report questionnaire evaluating symptoms of major depressive disorder according to the criteria of the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders, the DSM-IV (American Psychiatric Association, 2000). Each PHQ-9 item corresponds to one of the nine DSM-IV symptoms of depression, rated in relation to the previous two weeks. Responses include: “Not at all” (0), “Several days” (1), “More than half the days” (2), and “Nearly every day” (3). The

PHQ-9 has good validity, test–retest reliability, and internal consistency (e.g., Kroenke et al. (2001)).

2.2.3. Primary and co-morbid diagnoses

Primary and co-morbid diagnoses were assessed in individual clinical interviews using the MINI (Sheehan et al., 1998), a structured diagnostic interview for DSM-IV and ICD-10 psychiatric disorders, which takes approximately 20 min to administer and is a valid and time-efficient alternative to the SCID-P and CIDI (Sheehan et al., 1997; Lecrubier et al., 1997).

2.3. The eye-tracking task

Color photographs of 16 male and 16 female actors, each contributing a disgusted and a neutral emotional facial expression, were taken from the Karolinska Directed Emotional Faces database (KDEF; Lundqvist et al. (1998)). We used disgusted expressions as social threat stimuli in accord with previous visual attention studies of SAD (for discussions, see Staugaard (2010) and Waechter et al. (2014)). From the KDEF set we selected the faces that ranked highest on disgusted expressed emotion (Goeleven et al., 2008), and did not expose teeth. To ascertain that findings do not uniquely reflect the specific characteristics of a specific set of actors we divided our pool of stimuli into two sets of eight male and eight female actors each, while ensuring similar average disgust expression scores in the two sets (i.e., set A and set B), which were then used in a counterbalanced manner across participants.

For each stimulus set we assembled 900×900 pixels, 4×4 matrices (16 faces), half with disgusted expression and half with neutral expression. Each face extended 225×225 pixels, including a 10 pixel white margin on every edge (see Fig. 1). Each face appeared randomly at any position on the matrix while ensuring the following: (a) each actor appeared only once in any single matrix; (b) each matrix contained eight male and eight female faces; (c) half of the faces were disgusted and half neutral; and (d) the four inner facial expressions always contain two disgusted and two neutral faces.

Each trial of the task began with a fixation-cross, shown until a fixation of 1000 ms was recorded by the eye-tracker devise, thus making sure that each trial began only when participants' gaze was fixated at the matrix's center. Then the matrix was presented for 6000 ms, followed by an inter-trial interval of 2000 ms until the next fixation cross appeared. Each participant observed 60 different matrices, presented in two blocks of 30 matrices each,

Fig. 1. An example of a single matrix. The eight disgusted faces comprise the threat area of interest (AOI) and the eight neutral faces comprise the neutral AOI.

with a break of one minute between blocks. Each block was preceded by a calibration of the participant's gaze. Each single facial expression had the same appearance prevalence within each block, that is, each facial expression appeared exactly 15 times per block.

2.4. Eye tracking measures

Eye tracking data was processed using SMI BeGaze native software (SensoMotoric Instruments, Inc., Teltow, Germany). Fixations were defined as at least 100 ms of stable fixation within 1degree visual angle. For each of the 60 matrices we defined two Areas of Interest (AOI's), one including the eight disgust facial expressions (i.e., the threat AOI) and one including the eight neutral facial expressions (i.e., the neutral AOI).

The following outcome measures were derived: (a) *latency* in milliseconds *to first fixation* was calculated by averaging the latency to first fixations for each of the AOIs. First fixation was defined as the next detectable fixation following the initial "cross fixation" at the start of each trial; (b) *first fixation location* was measured by counting the number of times the first fixation was located in each AOI; and (c) *first fixation dwell time* was computed by averaging first fixation duration, in milliseconds, for each of the AOIs. Finally, *total dwell time* per defined AOI (threat/neutral) was calculated as the averaged total dwell time of each of the AOI's across the 60 matrices, reflecting continuous gaze allocation to either threat or neutral stimuli.

2.5. Apparatus

Eye movements and gaze data were recorded using a remote high speed eye-tracker (RED 500, SensoMotoric Instruments, Inc., Teltow, Germany), with a sampling rate of 500 Hz. Operating distance to the eye-tracking monitor was 70 cm. The stimuli were presented on a 22 in. Dell P2213 monitor with a screen resolution of 1680×1050 pixels.

2.6. Procedure

Participants were tested individually in a small and quiet room at the university. They were told that they are going to participate in a study examining gaze patterns using an eye-tracker apparatus. After signing an informed consent participants were seated in front of the eye-tracking monitor. The experimental procedure was designed and executed using the Experiment Center software provided by SMI. Before the start of the experiment participants were randomly assigned to either set A or set B of the eye-tracking task. Initially, a 5-point calibration was performed, followed by 4-point validation, providing the required reference data for computing gaze positions. The calibration procedure was repeated if visual deviation was above 0.5° on the *X* or *Y* axis. The experiment did not ensue until such calibration parameters were achieved. All participants were able to achieve this criterion.

Next, participants were told that during the experiment they would be presented with different matrices of faces, appearing one after the other, and were shown an illustration matrix as an example. They were informed that before the appearance of each matrix a fixation cross will appear at the center of the screen, on which they should fixate their gaze in order to make the matrix appear, and then were presented with a demonstration of this contingency. After these general explanations participants were instructed to look freely at each matrix in any way they chose until it disappeared.

Following the completion of the eye tracking task participants were requested to fill out the LSAS and PHQ-9 questionnaires. At the end of the session high and low SA participants were invited to take part in a second session (Session 2), held exactly one week later, while participants with clinical SAD were referred to the clinic to begin therapy as scheduled. The procedure of Session 2 for the students sample followed the same protocol as in Session 1, using new matrices from the same set of actors. All participants were thanked for participation and debriefed as to the aim and purpose of the study.

2.7. Data analysis

To examine group differences in latency to first fixation, first-fixation location, and first fixation dwell time, as well as total dwell time on threat/neutral AOIs, we performed separate mixed-model analyses of variance (ANOVAs) with group (high SA, low SA, clinical SAD) as a between subjects factor and AOI (threat, neutral) as a within subject factor. Follow-up analyses for significant interactions included separate one-way ANOVAs for the threat and neutral AOIs, with follow-up contrasts to further explicate group differences. In addition, to further clarify the findings we performed analysis of covariance (ANCOVA) for significant findings entering depression scores from the PHQ-9 as the covariate to the above described main analyses. All statistical tests were 2-sided, using α of.05. Effect sizes are reported using η_p^2 values for conducted ANOVAs. For significant findings a 95% confidence interval (CI) is also reported.

3. Results

3.1. Eye-tracking data

3.1.1. Set type

We compared scores on all of the eye-tracking variables between sets A and B, overall and within each group. The results revealed no significant differences between the sets, all $ps > .12$. Therefore, we collapsed across set-type in all analyses.

3.1.2. First fixation

Non-significant group-by-AOI interaction effects were noted for first fixation latency, $F(2, 57)=.03$, $p=.97$, $\eta_p^2=.001$, first fixation location, $F(2, 57)=.34$, $p=.71$, $\eta_p^2=.01$, or first fixation dwell time, $F(2, 52)=1.12$, $p=.33$, $\eta_p^2=.04$. There were no main effects of group or AOI for these measures either.

3.1.3. Continuous gaze allocation (total dwell time)

Total mean dwell times, in milliseconds, by group and AOI are presented in Fig. 2. A main effect of AOI, $F(1, 57)=8.22$, $p=.02$, $\eta_p^2=.12$, indicates that participants spent less time fixating on the threat faces ($M=1870$, $SD=463$, 95% CI [1750, 1990]) compared with the neutral faces ($M=2122$, $SD=471$, 95% CI [2001, 2244]). However, this main effect was qualified by a significant group-by-AOI interaction effect, $F(2, 57)=3.88$, $p=.02$, $\eta_p^2=.12$, indicating differential dwell time patterns for the three groups with regard to the threat and neutral AOIs. Separate follow-up one-way ANOVAs on total dwell time for the threat and neutral AOIs revealed a significant difference between the groups on the threat AOI, $F(2, 57)=3.68$, $p=.03$, $\eta_p^2=.12$, but not on the neutral AOI, $F(2, 57)=1.11$, $p=.34$, $\eta_p^2=.03$. Follow-up contrasts of total dwell time on the threat AOI revealed that the high SA group ($M=1969$, $SD=411$, 95% CI [1776, 2162]) and the SAD group ($M=1990$, $SD=516$, 95% CI [1749, 2232]) spent significantly more time fixating on the threat faces compared with low the SA group ($M=1650$, $SD=393$, 95% CI [1466, 1835]), $F(1, 57)=5.14$, $p=.03$, $\eta_p^2=.09$, and $F(1, 57)=5.86$, $p=.02$, $\eta_p^2=.09$, respectively. There were no significant differences

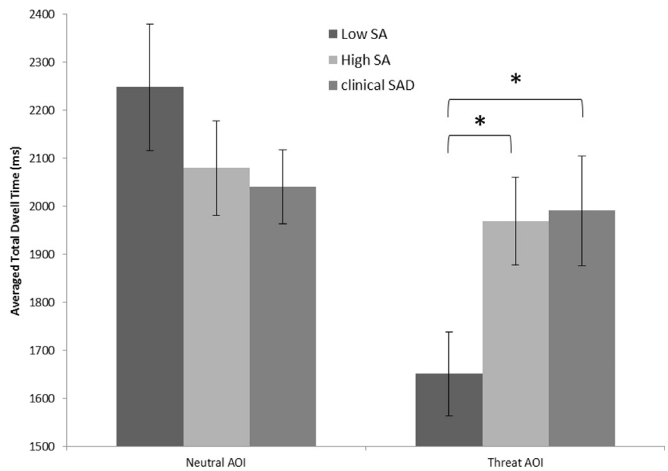

Fig. 2. Mean averaged total dwell time by AOI and Group. Higher values indicate higher dwell time in milliseconds. Error bars denote standard error. High social anxious (SA) and clinical social anxiety disorder (SAD) participants spent significantly more time fixating on the threat AOI in comparison to low SA participants. There were no significant differences in dwell time on the neutral AOI.

between the high SA and the SAD groups, $F(1, 57)=.02$, $p=.88$, $\eta_p^2<.001$.

Because the three groups differed on self-reported depression (see Table 1), and as the low SA and clinical SAD groups also differed on age, we repeated the above analyses introducing PHQ-9 depression scores and age as covariates. The group-by-AOI interaction effect remained significant, $F(2, 55)=3.39$, $p=.04$, $\eta_p^2=.11$, as did the one-way ANOVA on total dwell time for the threat AOI, $F(2, 55)=4.51$, $p=.01$, $\eta_p^2=.14$. The follow-up contrasts of total dwell time on the threat AOI also remained significant, $F(1, 55)=6.84$, $p=.01$, $\eta_p^2=.11$, for the difference between the high and low SA groups, and, $F(1, 55)=6.29$, $p=.01$, $\eta_p^2=.10$, for the SAD vs. low SA group.

Analyses of Session 2 data for the student sample (held one week after Session 1) revealed non-significant group-by-AOI interaction effects for first fixation measures, all $ps>.10$. And, as in Session 1, a significant group-by-AOI interaction was found for total dwell time, $F(1, 37)=5.45$, $p=.02$, $\eta_p^2=.13$. Follow-up contrasts of total dwell time on the threat and neutral AOIs revealed that the high SA group spent more time fixating on the threat faces ($M=1950$, $SD=403$, 95% CI [1760, 2138]), compared with low the SA group ($M=1670$, $SD=273$, 95% CI [1534, 1802]), $F(1, 37)=6.34$, $p=.02$, $\eta_p^2=.14$. No significant difference was found regarding time spent fixating the neutral faces, $F(1, 37)=.12$, $p=.73$, $\eta_p^2=.003$.

3.2. *Internal consistency and test–retest reliability of total dwell-time measures*

Internal consistency for total dwell time on threat faces, total dwell time on neutral faces, and the percentage of total dwell time on threat faces out of total dwell time spent on both threat and neutral faces for the 60 matrices presented in Session 1 was high, with Cronbach's alphas of .95, .95, and .91, respectively. Internal consistency remained high in Session 2, conducted one week later, with Cronbach's alphas of .89, .92, and .94, respectively.

One week test–retest reliability was significant for: total dwell time on threat faces, total dwell time on neutral faces, and the percentage of total dwell time on threat faces out of total dwell time spent on both threat and neutral faces, $rs(39)=.68$,.62, and.63, respectively, $ps<.001$. Test–retest reliabilities for latency to first fixation, first fixation location, and first fixation dwell time were non-significant, $rs(39)=.06$, .26, and .08, respectively, $ps>.1$.

4. Discussion

The present study was designed to examine gaze patterns in relation to social threatening stimuli among socially anxious individuals. We employed a free-viewing task, comprised of multiple competing threat and neutral stimuli presented for an extended time period, during which we recorded participants' eye gaze data. We further tested the psychometric properties of our task, as to date only few eye-tracking studies have reported internal consistency analysis, with none examining test–retest reliability (Waechter et al., 2014).

The current study shows that individuals with high SA and participants with clinically diagnosed SAD dwell longer on threat faces relative to nonanxious participants, reflecting a visual attention bias toward threatening faces in socially anxious individuals over time. The fact that the high SA group and the clinical SAD group exhibited similar threat-related gaze patterns is not surprising given the high LSAS scores of high SA participants. It is reasonable to assume that these high SA students, although not actively seeking psychological treatment from our clinic, dealt with similar social anxiety levels as did participants in the clinical SAD group. The current results also indicate that high SA, low SA, and participants with clinically diagnosed SAD did not differ on any of the first-fixation variables, be it latency, location, or dwell time, nor did the groups differ in total dwell time on neutral faces. Finally, the current findings reflect no effect of depression on viewing patterns, thus suggesting specificity of our results to SAD. Taken together, the results suggest a specific bias to sustain attention on social threat (disgusted faces) in social anxiety.

The current results are in line with previous studies that also found evidence for increased dwell time on socially threatening stimuli among socially anxious individuals (e.g., Buckner et al. (2010), Schofield et al. (2012) and Wieser et al. (2009)), while using a large set size of multiple competing stimuli, with similar effect sizes to those reported in previous free-viewing eye-tracking studies (e.g., Stevens et al. (2011), Waechter et al. (2014) and Wieser et al. (2009)). However, unlike some previous studies (e.g., Bradley et al. (2000), Gamble and Rapee (2010), Garner et al. (2006) and Stevens et al. (2011)), we did not find evidence for group differences on any of the first fixation indices (latency, location, and dwell time). A possible reason for this non-replication might be related to difference in the number of competing stimuli presented to participants. Previous studies have mostly used two competing stimuli, one threatening and one neutral presented side-by-side, whereas the present task used an array of 16 stimuli comprised of eight socially threatening faces and eight neutral faces. Armstrong and Olatunji (2012) suggested that first fixation variables, especially fixation location, are strongly affected by the number of presented stimuli (e.g., Yates et al. (2010)). Thus, anxiety-related differences in first fixation measures might emerge only when participants are presented with simple and limited visual displays (Richards et al., 2014). Indeed, the current null findings regarding first fixations are consistent with other studies using more complex arrays of stimuli that also did not find evidence for first fixation biases in anxious individuals (e.g., Derakshan and Koster (2010), Huijding et al. (2011) and Waechter et al. (2014)).

The current task has acceptable test–retest reliability, as well as high internal consistency, not usually found in most RT tasks measuring attention bias (e.g., Schmukle (2005), Staugaard (2009), Van Bockstaele et al. (2014) and Waechter et al. (2014)) and typically not reported in eye tracking studies (cf. Waechter et al. (2014)). The acceptable psychometric properties of the current eye-tracking task in socially anxious and nonanxious participants and the stable group difference in total dwell time on threat faces could provide a solid platform for the development of novel eye-tracking-based attention bias modification treatments. Specifically, because the current task has no explicit requirements from participants it may reduce the performance demands that characterize attention bias modification tasks targeting specific components of attentional bias, and instead potentially capture more naturalistic scanning patterns of environmental threat. The current findings reveal gaze patterns occurring over extended periods of time (seconds rather than milliseconds), while participants with social anxiety continuously scan complex social stimuli. This particular aberration in threat monitoring could become a viable target for therapeutic intervention.

Some limitations of the present study call for further exploration in future research. First, we employed a relatively small sample size, particularly for the SAD group. Despite the small sample size significant results emerged, demonstrating different gaze patterns between socially anxious and non-anxious participants. Furthermore, the similar gaze patterns of the high SA and SAD groups in relation to dwell time on threat stimuli offer convergent validity for this observation. Still, larger samples may increase the power to detect group differences in some of the first fixation measures we tested. Second, the three groups were not matched on age, rendering age as a possible factor influencing our results, especially those regarding the difference found between the non-anxious group (i.e., the low SA group) and the SAD group. However, this possibility is unlikely as evident by the similar performance patterns of the high SA and SAD groups, despite their age differences, and the differences in gaze patterns found between the high and low SA groups, despite having a similar age. Furthermore, the findings remained the same when including age as a covariate in analyses. Third, the stimulus matrices applied in the current study included only disgust and neutral facial expressions, with no other emotional expressions. Future studies could use positive as well as other negative facial expressions embedded in the experimental matrices to further elucidate the specificity boundary of disgusted expression in the context of social anxiety. Finally, the current study focused on socially anxious and non-anxious participants. However, the same task might yield similar gaze patterns for other psychopathologies (e.g., GAD, depression, PTSD). Future research using the current task to study patients with other psychopathologies is important in order to determine the specificity of the observed findings to social anxiety. In a related vein, future studies could also test whether effects sizes of differences between anxious and non-anxious participants are larger when content-specific stimuli, tailored for specific anxiety disorder in question, are used (Pergamin-Hight et al., 2015).

Current findings may serve as a preliminary stepping stone for the development of novel attentional bias modification treatment for SAD. The evidence indicate that socially anxious individuals tend to dwell longer on threatening social stimuli, a viewing pattern possibly reflecting heightened monitoring of threat over time. Therefore, this heightened threat monitoring may be a viable target for therapeutic intervention. Future studies could examine the potential therapeutic effect of diverting the gaze patterns of socially anxious individuals to neutral over threatening stimuli by using, for example, gaze-contingent reward (e.g., Price et al. (2015)).

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